COST AND PERFORMANCE REPORT

Vacuum-Enhanced, Low-Temperature Thermal Desorption
at the FCX Washington Superfund Site
Washington, North Carolina

September 1998

EPA

Prepared by:

U.S. Environmental Protection Agency
Office of Solid Waste and Emergency Response
Technology Innovation Office

SITE INFORMATION

Identifying Information:

FCX Washington Superfund Site
Washington, North Carolina

CERCLIS # NCD981475932

Action Memorandum Date:
September 29, 1988

Treatment Application:

Type of Action: Removal

EPA SITE Program Test Associated With Application? No

Period of Operation: March 1995 - March 1996

Quantity of Material Treated During Application: 13,591 cubic yards

Background

Waste Management Practice That Contributed to Contamination: Burial of outdated and out-of-specification mixed pesticides in trenches.

Site History [4, 5]:

From 1945 to 1982, the Farmers Cooperative Exchange (FCX) operated a pesticide blending facility and warehouse where it packaged pesticides. The pesticides most frequently handled at the site were chlorinated organic pesticides including chlordane, methoxychlor, dichloro-di-phenyltrichloroethane (DDT), and 1,1-dichloro-2,2-bis(4-chlorophenyl) ethene (DDE). Various other chlorinated and nonchlorinated organic chemicals were used in mixing and blending of pesticides. Outdated or out-of-specification materials were buried in trenches on the FCX property. In 1985, the company filed for bankruptcy, and the building and warehouses were cleaned out. In 1986, the Fred Webb Grain Company (FWGC) purchased approximately 15 acres of the FCX property to be used to store grain under the federal government grain subsidy program.

Subsequent investigations of the site performed by EPA and the state indicated that the site was contaminated with pesticides. In January 1989, EPA Region 4 initiated a removal action. Approximately 2,200 cubic yards of debris and soils contaminated with pesticides were excavated and disposed off site. The site was listed on the NPL in March 1989.

The removal site investigation, performed in 1992, identified pesticide contamination in trenches at the site. Approximately 14,700 cubic yards of contaminated soil (total chlorinated pesticides above 1 mg/kg) were excavated and stock piled for on-site incineration. As a result of objections by the city to the use of on-site incineration and in response to state issues regarding off-site disposal, EPA identified on-site thermal desorption as the remedy for the excavated contaminated soil at FCX.

Regulatory Context:

The removal action at the FCX site was performed under an action memorandum signed September 29, 1988. As a result of the issues identified above with respect to on-site incineration and off-site disposal, EPA made the decision to use on-site thermal desorption as the remedy.

In July 1994, the agency issued a request for proposal (RFP) for an on-site thermal desorption system to remove the contaminants from the soil. To support the selection of an on-site thermal desorption unit, the agency prepared technical specifications that included:

1. Elimination of oxygen within the unit (less than five percent) during treatment to reduce the potential for formation of dioxins and furans during thermal desorption

2. Recycling of the unit's air stream or use of a low-flow system to minimize the amount of gas discharged to the atmosphere

SITE INFORMATION (CONT.)

3. Exclusion of any type of device that allows combustion to take place in the presence of the contaminants

4. Use of a low-temperature condenser

5. Discharge flow of less than 500 actual cubic feet per minute (acfm), cooling of the emissions stream, and use of an indirect-fired system

Remedy Selection: On-site thermal desorption

Site Logistics/Contacts

Site Management: Fund Lead

Oversight: EPA

On-Scene Coordinator (OSC):
Paul Peronard*
EPA Region 4
345 Cortland Street, N.E.
Atlanta, GA 30365
Telephone: (404) 562-8767

State Contact:
Randy McElveen
North Carolina Department of Environment, Health, and Natural Resources, Superfund Station
P.O. Box 27687
Raleigh, NC 27611
Telephone: (919) 733-2801

ERCS Site Assessment Contractor:
Sara Legard
Four Seasons Industrial Services, Inc.
3107 South Elm-Eugene Street
P.O. Box 16590
Greensboro, NC 27416
Telephone: (910) 273-2718

Treatment System Vendor:
Nanette Orr
McLaren/Hart Environmental Engineering Corporation
Great Woods Park
800 South Main Street
Mansfield, MA 02048
Telephone: (508) 261-1515

* Primary point of contact for this application.

MATRIX DESCRIPTION

Matrix Identification

Type of Matrix Processed Through the Recovery System: Soil (ex situ)

Contaminant Characterization

Primary Contaminant Groups: Pesticides

Soil samples were collected from soil above the trench and inside the trench and analyzed for pesticides. Table 1 presents the results of analyses of soil samples.

Table 1: Contaminants and Concentrations in Soil [5]

Contaminant	Range (mg/kg)
Above the Trench	
Aldrin	27.0 - 1585.0
Chlordane	1.0 - 50.0
DDT	1.0 - 37.7
DDE	1.0 - 37.7
Mercury	0.0 - 28.0
In the Trench	
Chlordane	1.0 - 6629.0
DDD	1.0 - 500.0
DDT	1.0 - 19435.0
DDE	1.0 - 47.0
Dieldrin	1.0 - 47.0
Heptachlor	1.0 - 79.0
Heptachlor epoxide	1.0 - 79.0
Methoxychlor	1.0 - <130.0
Total benzene hexachlorides (BHC) (alpha BHC and gamma BHC)	1.0 - 189.0

MATRIX DESCRIPTION (CONT.)

Matrix Characteristics Affecting Treatment Cost or Performance

Table 2 presents the major characteristics of the matrix that affected the cost or performance of this technology and the values measured for each.

Table 2: Matrix Characteristics [11, 12]

Parameter	Value
Soil classification/ particle size distribution	Silty Sand (Augusta fine)
Moisture content	Less than 15 percent most of the time. Approximately 15 to 20 percent during final phase of project.
Oil and grease or total petroleum hydrocarbons (TPH)	Information not provided
Bulk density	Information not provided
Lower explosive limit	Information not provided

Soil was generally a silty sand that was fairly homogenous in nature and that required no processing before thermal treatment. Soil moisture had a significant effect on the length of the treatment cycle. Rate of transfer of heat was regulated primarily by the percentage of contained moisture. The average moisture content of the soil during most of the treatment program was less than 15 percent. During the final phase of treatment (December 1995 to March 1996), inclement weather increased the moisture content of the soil, which during that period was estimated to be between 15 to 20 percent, with an average of approximately 18 percent. The higher moisture content increased the length of the treatment cycle [11].

DESCRIPTION OF THE TREATMENT SYSTEM

Primary Treatment Technology

Vacuum-enhanced, low-temperature thermal desorption

Supplemental Treatment Technology Types:

Post-Treatment (Air): Dry particulate filter (DPF), condenser with chiller, carbon adsorption

Post-Treatment (Water): Reverse osmosis (R/O), carbon adsorption

System Description and Operation

System Description [1, 10, 12, 13]

Vacuum-enhanced, low temperature thermal desorption (LTTD) was used to treat the contaminated soil at the FCX site. Figure 1 shows the components of the model IRHV-200 mobile LTTD system used at the site, which consisted of a treatment chamber and emission control equipment including a dry particulate filter, condenser, and carbon adsorption unit.

The IRHV-200 LTTD system used infrared heat to desorb high-boiling point contaminants from the soil matrix and air to "strip" target contaminants from the soil matrix. The treatment chamber was operated under vacuum conditions to lower the effective boiling points of the target contaminants.

According to the vendor, by operating under a vacuum, the temperature required to desorb contaminants from the soil and the amount of oxygen present in the treatment chamber were lower than if the unit were operated under atmospheric condition. In addition, operating under low oxygen (anaerobic) conditions helped reduce the potential for formation of dioxins and furans.

A description of the major components of the system is presented below.

Description of the Treatment System (cont.)

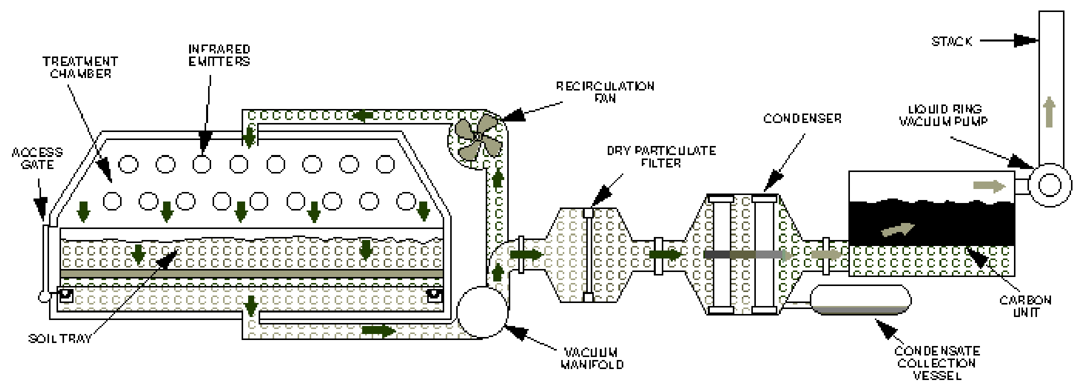

Figure 1. Major System Components of the IRHV-200

Four treatment chambers were used in this application. The treatment chamber was equipped with two bins, each measuring 8 feet wide by 8 feet long by 18 inches deep (2.5 cubic yards). Each bin was constructed of carbon steel sidewalls and a stainless steel, perforated base with 0.001" slots per square inch (46% open space) to allow for downward flow of air through the soil into two 4" x 20" air exhaust outlets centrally located in the base of each bin. Each bin was loaded with contaminated soil outside the chamber, placed into the treatment chamber by a wheel loader, and placed on top of the unit's internal support system inside the treatment chamber.

Eight individual infrared units arranged in parallel rows were used to generate infrared energy. During operation, thin-walled aluminized steel tubes were heated to approximately 1,100°F. At that temperature, each aluminized steel tube emitted energy in the infrared spectrum at the rate of approximately 137,500 British thermal units per hour (Btu/hr) for a total system output (infrared energy) of approximately 1.1 million Btu/hr. Generally, within 30 minutes, the surface of the soil was heated to over 250°F with a goal of heating to a minimum of 350°F

A liquid seal vacuum pump was used to create a vacuum of about 50 mmHg within each treatment chamber. As shown in Figure 1, each chamber was equipped with a high flow recirculation fan or blower, that was used to draw air through the soil in the treatment chamber to promote heat transfer. Air was drawn through outlets at the bottom of the chamber and returned to the chamber through air inlets at the top of the chamber. Air was drawn off of the recirculation air stream using the vacuum pump (rated at approximately 300 acfm) and directed to the emissions control system, as shown in Figure 1.

The dry particulate filters (DPFs) were in-line, static microfiltration elements (less than 10 microns) used to minimize the accumulation of particulates in the downstream air emission control equipment, such as condenser and carbon units and to control the release of smoke and particulates to the atmosphere. The DPFs were installed in the recirculation loop before the inlet for the primary condenser. The DPFs were designed to receive an air stream as high as 6,000 acfm at a maximum temperature of approximately 500°F.

Description of the Treatment System (cont.)

A primary condenser, installed between the treatment chamber and the vacuum pump, received an air stream at a flow rate of approximately 6,000 acfm (per treatment chamber) and a maximum temperature of approximately 400°F. The temperature of that air stream was reduced to approximately 40°F and passed through a velocity dissipator that functioned as a moisture separator to remove any residual water from the air stream. The majority of air exiting the primary condenser (5,400 acfm) was recirculated back into the treatment chambers (not shown on Figure 1). The balance of the air (600 acfm) was directed to the secondary condenser and carbon polishing system.

The temperature of the air stream was reduced to less than 32°F by the secondary condenser. Approximately 350 tons of chilling capacity was required at the FCX site. All condensate (water and contaminants) was transferred to a general collection vessel by a transfer pump. The condensable products were transferred from the collection tank to a 20,000-gallon Frac tank by an electrically powered transfer pump.

The air stream was passed through a vapor-phase carbon adsorption polishing system before it was discharged to the atmosphere. The system was charged with a single carbon adsorption unit that contained 2,000 pounds of activated carbon and was designed for mass flows as high as 100 acfm.

System Operation [1, 2, 3, 9, 10, 11, 12, 13]

McLaren/Hart conducted two site demonstrations before full-scale operations began. One hundred yd^3 of contaminated soil were treated during the demonstration program; analyses of total pesticides in the treated soil was performed for three lots. The initial demonstration, conducted with a batch of clean soil, failed to heat the soil throughout. Only the top 6 inches of 16 inches of soil in the treatment chamber reached 300° F. McLaren/Hart investigated several methods to improve the heat transfer. These included:

- Piping the exhaust gas from the propane unit through the bottom of the treatment chamber. However, this was not effective in increasing the temperature of the soil.
- Varying the depth of the soil in the treatment chamber. While this increased the rate of heat transfer, the throughput of the system was reduced.
- Adding a mechanical agitation system to increase the amount of heat transfer through the soil. A fan-type system was initially used. However, this turned the soil to powder after about an hour. The system was subsequently altered to use a hydraulically driven propeller for mechanical agitation.
- Adding an in-line blower to increase the air flow rate within the treatment chamber to 6,000 acfm and increasing the volume of air passing through the chamber, thereby improving the heat transfer through the soil.

As a result, the following design changes were made:

- The blower pump was increased in size from 30 to 300 hp.
- Mechanical agitations were added to the soil trays.
- A 6,000 acfm recirculation blower was added in-line after the primary condenser.
- Infrared heaters were added to the bottom of treatment chamber number four.

Full-scale operation started on April 26, 1995. Beginning in July of 1995, McLaren/Hart shut down the system for 3-4 hours per day as part of a power saver agreement with the local electric company. During September 1995, McLaren/Hart modified one of the treatment chambers by adding infrared heating tubes underneath the soil tray to help reduce the treatment time.

DESCRIPTION OF THE TREATMENT SYSTEM (CONT.)

When all of the soil reached the desired temperature of 350° F, the temperature was held at that level for five minutes. The treatment time was recorded, and the infrared heat source for the treatment chamber was deactivated manually. Before the heat source was deactivated, the vacuum pump remained operational for an additional 30 seconds to one minute to ensure that the chamber had been flushed of any fugitive emissions. The material bins then were removed from the treatment chamber. The treated soil was stockpiled and held until analytical data confirmed that it met cleanup levels.

The system was operated 24 hours/day for 7 days/week. The average treatment cycle was approximately 4.0 hours/treatment chamber. Each unit had a capacity of 6.0 hours/treatment chamber. With all four treatment units operational, the average treatment cycle was 6.0 tons/hr.

In total, McLaren/Hart treated 13,591 cubic yards of contaminated soil. After the results of analysis of post-treatment confirmatory soil samples were received, the treated soil was transported outside the treatment zone and stockpiled for eventual beneficial reuse by the city of Washington, North Carolina.

At the FCX site, all condensate generated was collected in a 20,000-gallon Frac tank. The condensate was treated by:

1. A phase separator
2. An iron-selective sand filter
3. A reverse osmosis unit (selective membrane)
4. A granular activated carbon polishing unit

The rated capacity of the system was approximately five gpm, with a discharge water quality of less than 10 ppb of hazardous organic compounds. The treated water was used to rehydrate the treated soil. Approximately 450,000 gallons of condensate (water and contaminants) were collected and treated at the site, resulting in the generation of thirty-three 55-gallon drums of pesticides and three 55-gallon drums of carbon from the water treatment system that required disposal at an off-site facility permitted under RCRA.

Operating Parameters Affecting Treatment Cost or Performance [1, 12]

Table 3 presents the major operating parameters that affected cost or performance of the technology and the values measured for each.

Table 3: Operating Parameters [1, 12]

Parameter	Value
Vacuum condition in treatment chamber	50 mm Hg
Energy output of total system (infrared energy)	1.1 million Btu/hr
Air flow rate for treatment chamber	300 acfm (6,000 acfm for recirculated air stream)
Temperature of infrared source	1,100° F
Total cooling capacity of chiller	350 tons
Flow rate for reverse osmosis system	1 to 4 gpm
Mass flow for carbon adsorption polishing system	Maximum 100 acfm
Residence time	4 hours/chamber (5 minutes at minimum of 350 °F)
System throughput	6 tons/hr
Soil temperature	350 - 400 °F

DESCRIPTION OF THE TREATMENT SYSTEM (CONT.)

Timeline

Table 4: Timeline [2, 3, 4, 5, 6, 7, 8, 12]

Start Date	End Date	Activity
March 31, 1989	---	The site was listed on the NPL.
September 29, 1988	---	Action memorandum signed.
1992	---	On the basis of the results of the RI, ERRB initiated excavation of 13,000 cubic yards of soil.
July 1994	---	EPA Region 4 issued an RFP for thermal desorption of 14,700 cubic yards of soil contaminated with pesticides.
November 28, 1994	---	Site mobilization began.
January 25, 1995	---	Using a batch of clean soil, the contractor conducted an initial site demonstration of the low-temperature, vacuum-enhanced thermal desorption unit.
February 1, 1995	---	The LTTDS system was 95 percent completed following modifications to increase uniform heating of soil and to operate the system under conditions specified in the contract.
March 16, 1995	---	The contractor was given approval by the OSC to conduct a second site demonstration program for treatment of contaminated soil by the LTTDS system after the system was modified to increase heat transfer through the soil.
March 20, 1995	April 20, 1995	The contractor completed treatment of 105 cubic yards of contaminated soil before a contract deadline of March 30, 1995.
April 26, 1995	March 12, 1996	The contractor conducted full-scale operation of the unit, treating approximately 13,591 cubic yards of contaminated soil in warehouses and stockpiled.
March 18, 1996	March 21, 1996	The LTTDS equipment was demobilized from the site.
August 30, 1996	---	The contractor submitted a final report on the project.

Treatment System Performance

Cleanup Goals/Standards [6]

The cleanup goal for the site was 1.0 mg/kg of total pesticides (per EPA method 8080 for organochloride pesticides and polychlorinated biphenyls [PCB]).

To confirm that the cleanup goals had been achieved, three independent grab samples were to be taken each day or from each 500-ton lot. Each of the three samples was to show concentrations below 1.0 mg/kg of total pesticides before the lot was to be considered treated successfully.

No permit was required to vent the carrier gas from the treatment system because the contaminants were expected to have negligible vapor pressures at 32 °F. An upper limit of approximately 150 mg/kg for total hydrocarbons was established for emissions for the carbon polishing system during full-scale operation.

Table 5 shows the standards the EPA Region 4 Air Compliance Section developed for the release of the vented carrier gas during the demonstration. A one-time stack air monitoring test was performed during the demonstration program. Three sample trains were obtained during the stack sampling and analyzed for volatile organic compounds, total pesticides, dioxins, furans, particulates, moisture, and volume of gas.

Table 5: Standards for Vented Air Emissions for Demonstration [6]

Compound	Maximum Concentration mg/dscm
Aldrin	0.25
Chlordane	0.5
DDT	1.0
Dieldrin	0.25
Heptachlor	0.5
Lindane	0.5
Methoxychlor	30.0

Performance Data and Data Assessment [12, 13]

Table 6 presents results of analyses of soil for the demonstration program. Results indicated that the LTTD met the cleanup goal of 1 mg/kg total pesticides in each of three lots. Data also showed that concentrations of dioxins or furans (toxicity equivalent) in the treated soil were less than in the untreated soil.

The results of the analyses of stack samples from the demonstration (Table 7) indicated that the concentrations for pesticides were below the EPA standards, as specified in Table 5. Dioxin and furan (toxicity equivalent) were reported at 1.180 x 10^{-9} mg/dcsm.

Table 8 shows post-treatment analytical data for full-scale operations. All samples of treated soil met the cleanup goal of 1.0 mg/kg total pesticides. The table shows the concentrations of total pesticides for the three composite samples for each of 43 stockpiles.

Emissions from the exhaust stack met the standards for discharges of total hydrocarbons from all four treatment chambers. The average FID reading for total hydrocarbon emissions ranged from 2.8 mg/kg to 142.7 mg/kg.

A total of 13,591 cubic yards of soils were treated. Less than one percent of soil required retreatment.

Performance Data Quality

The quality assurance and quality control (QA/QC) program conducted throughout the remedial action met the requirements of both EPA and the state of North Carolina. Methods approved by EPA were used in performing all monitoring. Results of all laboratory analysis were submitted with a Level III data quality package; results of analyses are on file with EPA Region 4 (Contract No. 68-54-4003). All soil analysis was performed by laboratories approved by EPA Region 4 (Kiber Environmental Services in Atlanta, Georgia, and Southern Testing in Wilson, North Carolina).

Treatment System Performance (cont.)

Table 6: Analytical Results of Soil Analysis for the Demonstration Program [12]

Contaminant	Lot	Pre-treatment concentration (mg/kg)	Post-treatment concentration (mg/kg)
Total Pesticides[1]	1 2 3	3226.0 57.2 57.7	0.0252 0.0292 0.187
Dioxins/furan (expressed as 2,3,7,8-TCDD toxicity equivalent)[2]	Composite sample from lots 1, 2, and 3	0.193×10^{-3}	0.0085×10^{-3}
Semivolatiles	Composite sample from lots 1, 2, and 3	0.571	Not available
RCRA metals Arsenic Barium Chromium Lead	Composite sample from lots 1, 2, and 3	 8.5 11.0 3.1 4.0	 Not available

Table 7: Results of Analysis of Emissions for the Demonstration Program [12]

Compound	Concentration (mg/dscm)	Mass Rate (lb/hr)
Particulate	0.035×10^{-3}	0.001
Dioxin and furan (expressed as 2,3,7,8-TCDD toxicity equivalent)	1.180×10^{-9}	1.40×10^{-11}
Semivolatiles	3.108×10^{-6}	1.345×10^{-4}
VOCs	2.202	1.125×10^{-3}
PCBs	1.236×10^{-4}	8.47×10^{-8}
Total Pesticides	6.744×10^{-3}	1.565×10^{-6}
Aldrin	0.083×10^{-3}	5.65×10^{-8}
Chlordane	0.115×10^{-3}	7.90×10^{-8}
DDT	$< 0.032 \times 10^{-3}$	$< 2.16 \times 10^{-8}$
Dieldrin	0.039×10^{-3}	2.64×10^{-8}
Heptachlor	0.016×10^{-3}	1.12×10^{-8}
Methoxychlor	$< 0.158 \times 10^{-3}$	$< 10.8 \times 10^{-8}$

1 Total pesticides consisted of alpha-BHC, gamma-BHC, dieldrin, endrin, 4,4'-DDD, 4,4'-DDT, aldrin, heptachlor epoxide, 4,4'-DDE, alpha-chlordane, gamma-chlordane, and toxaphene. Lot 1 contained 56 mg/kg of 4,4'-DDD and 3,170 mg/kg of toxaphene.

2 Total dioxin concentration was expressed as 2,3,7,8-TCDD toxicity equivalent. The pretreatment concentration of total dioxin was 0.193×10^{-3} mg/kg. Individual concentrations of dioxin before treatment were 7.14×10^{-3} mg/kg of 1,2,3,4,6,7,8-HPCDD and 122×10^{-3} mg/kg of 1,2,3,4,6,7,8,9-OCDD. The post-treatment concentration of total dioxin was 0.0085×10^{-3} mg/kg. Individual concentrations of dioxin after treatment were 0.36×10^{-3} mg/kg of 1,2,3,4,6,7,8-HPCDD and 4.88×10^{-3} mg/kg of 1,2,3,4,6,7,8,9-OCDD.

TREATMENT SYSTEM PERFORMANCE (CONT.)

Table 8: Summary Log of Post-Treatment Analyses [13]

Treatment stockpile no.	Cleanup goal (mg/kg)	Concentration of total pesticides in composite[1] sample 1 (mg/kg)	Concentration of total pesticides in composite[1] sample 2 (mg/kg)	Concentration of total pesticides in composite[1] sample 3 (mg/kg)	Average FID reading for total hydrocarbons (mg/kg)
1	1.0	0.019	0.095	0.071	30.9
2	1.0	0.30	0.044	0.037	51.1
3	1.0	0.129	0.132	0.149	53.6
4	1.0	0.099	0.103	0.093	61.2
5	1.0	0.275	0.250	0.287	142.7
6	1.0	0.197	0.235	0.156	54.9
7	1.0	BQL	BQL	BQL	78.5
8	1.0	BQL	BQL	BQL	48.6
9	1.0	BQL	BQL	BQL	16.5
10	1.0	0.006	0.006	0.150	3.2
11	1.0	BQL	BQL	BQL	3.1
12	1.0	0.015	0.043	0.051	13.80
13	1.0	BQL	BQL	BQL	14.30
14	1.0	BQL	BQL	BQL	34.7
15	1.0	BQL	BQL	BQL	8.3
16	1.0	0.004	0.017	BQL	9.8
17	1.0	0.036	0.034	0.038	8.3
18	1.0	0.028	0.037	0.044	7.7
19	1.0	0.006	0.012	0.071	8.3
20	1.0	0.139	0.097	BQL	5.5
21	1.0	0.018	0.086	0.110	6.0
22	1.0	0.012	0.035	0.032	7.0
23	1.0	0.065	0.023	0.039	6.8
24	1.0	0.070	0.060	0.030	6.6

TREATMENT SYSTEM PERFORMANCE (CONT.)

Table 8 (continued): Summary Log of Post-Treatment Analyses [13]

Treatment stockpile no.	Cleanup goal (mg/kg)	Concentration of total pesticides in composite[1] sample 1 (mg/kg)	Concentration of total pesticides in composite[1] sample 2 (mg/kg)	Concentration of total pesticides in composite[1] sample 3 (mg/kg)	Average FID reading for total hydrocarbons (mg/kg)
25	1.0	0.160	0.190	0.170	6.6
26	1.0	0.063	0.072	0.083	6.2
27	1.0	0.110	0.043	0.110	5.2
28	1.0	0.027	0.061	0.172	6.1
29	1.0	0.131	0.075	0.213	7.6
30	1.0	0.090	0.019	0.075	6.8
31	1.0	0.112	0.091	0.081	8.0
32	1.0	0.102	0.034	0.082	7.2
33	1.0	0.040	0.086	0.045	8.3
34	1.0	BQL	BQL	BQL	6.7
35	1.0	BQL	BQL	BQL	5.4
36	1.0	0.036	BQL	BQL	6.3
37	1.0	0.032	0.180	0.080	6.3
38	1.0	0.765	0.998	0.539	5.4
39	1.0	BQL	BQL	BQL	7.0
40	1.0	BQL	BQL	BQL	7.5
41	1.0	0.030	BQL	BQL	4.7
42	1.0	BQL	BQL	BQL	4.3
43	1.0	0.039	0.008	BQL	2.8

1 Independent composite sample was taken from each 500-ton lot.

COST OF THE TREATMENT SYSTEM

Procurement Process

The lead agency for the site was EPA Region 4. A lump sum contract for $1,247,000 was issued to McLaren/Hart on September 16, 1994 for the remediation of approximately 14,700 cubic yards of soil.

Initial oversight was performed by EPA Region 4. After successful completion of the demonstration program, and at the midpoint of full-scale treatment operations, EPA Region 4 contracted with the U.S. Coast Guard for daily oversight.

Costs [9]

Table 9 presents the costs reported by the vendor for the thermal desorption application at the FCX Washington Superfund site. Costs incurred to implement modifications of the system necessary to improve the heat transfer rate are presented as equipment costs.

Table 9: Summary of Costs [12]

Cost Element	Cost ($ in 1996)
Excavation (of soil)	**Included with capital costs**
Capital	
Mobilization/Demobilization	
- Mobilization of equipment	65,000
- Site closure and demobilization	20,000
Site Work/Preparation	
- Site preparation (permits not required)	15,000
Equipment and Appurtenances	
- Equipment modifications/rentals	907,200
Start-up and Testing	
- Performance evaluation	30,000
Capital Subtotal	**1,037,000**

COST OF THE TREATMENT SYSTEM (CONT.)

Table 9 (continued): Summary of Costs [12]

Cost Element	Cost ($ in 1996)
Operation and Maintenance	
Direct Labor	
- Labor	453,000
- Subcontractors	75,600
Direct Materials (includes utility and fuel costs)	
- Utilities	150,000
Health and Safety	
- Miscellaneous and health and safety	71,000
Analytical (related to technology performance, not compliance monitoring)	
- Treatment verification	40,000
O&M Subtotal	**789,600**
Disposal of Residuals	
- Waste disposal	18,000
Analytical (related to compliance monitoring, not technology performance)	**Included under O&M**
Total Project Cost	**1,844,600**
Other	
- EPA oversight (estimated at 480 days at $500)	240,000

The total reported cost for this application, without oversight was $1,844,800, including $1,696,800 for costs directly associated with treatment. Based on treating 13,591 cubic yards of soil, this corresponds to a unit cost of $125 per cubic yard.

However, the contract was issued as a fixed-price (lump sum) contract for $1,247,000. While the costs incurred by the vendor were $1,844,800, EPA paid only the $1,247,000 amount. The cost overrun of $597,800 was borne by the contractor.

The primary reason for the contractor's cost overruns was the extended treatment cycle required because of limitations in the convective heat transfer rate in the treatment chamber at elevated vacuum pressures. All costs for modifications of the system to improve the heat transfer were borne by McLaren/Hart.

Quality Of Cost Data

Costs included in this report are estimates provided by McLaren/Hart.

Observations and Lessons Learned

Cost Observations and Lessons Learned

McLaren/Hart stated that the initial system design could have been improved and conduct of more treatability studies at the start of the cleanup phase would have resulted in an improved initial system design that would have required fewer modifications during full-scale operation.

The OSC indicated that McLaren/Hart considered the cost overrun a research and development cost for optimizing its technology.

Performance Observations and Lessons Learned

The results of the demonstration indicated that the LTTD system could achieve the specified cleanup goal of 1.0 mg/kg total pesticides for the contaminated soil at the FCX site. The results of a one-time stack test met the EPA Region 4 standards for vented air emissions.

One of the objectives of operating the system under vacuum was to allow treatment to occur at lower soil temperatures and under low oxygen conditions to reduce the potential of formation of dioxins and furans. Data on stack emissions from the demonstration showed a very low mass rate for dioxin and furans of 1.4×10^{-11} lb/hr.

For the full-scale application, the cleanup goals were met for the 43 stockpiles of soil treated (13,591 cubic yards). Less than one percent of the soil required retreatment.

Other Observations and Lessons Learned [2, 3, 10, 13, 14]

After the application of LTTD at the FCX site, McLaren/Hart made a number of modifications to the system. These included:

- Increasing the size of the infrared units from 137,500 BTU/hr to 1.5 million BTU/hr.
- Replacing the thin-walled aluminized steel heating elements with heavier gauge cast iron to reduce metal fatigue and to improve heat transfer rate which allows for shorter treatment cycles.
- Eliminating the primary condenser in the recirculation loop. McLaren/Hart determined that there was no benefit to removing water and contaminants from the air stream prior to recirculation to the treatment chamber. In addition, McLaren/Hart found that without the primary condenser, the heat capacity of the air stream was higher, reducing energy use.

McLaren/Hart determined that continuous operation of the IRHV-200 system at elevated vacuums was not cost-effective. Rather, significant improvement in treatment cycle times was achieved by “ramping” to the desired treatment temperature initially under low-vacuum conditions (2 to 4 inches Hg). Once the target treatment temperature is achieved, full vacuum is applied to the treatment chamber to attain 50 mm Hg of pressure. This procedure reduced the overall length of the treatment cycle.

McLaren/Hart reported using the modified IRHV-200 system and revised operating parameters to successfully treat contaminated soil at other sites, including soils contaminated with pesticides and mercury.

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<u>Preparation of the Analysis</u>

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